REPORT

FROM

THE SECRETARY OF THE NAVY,

COMMUNICATING,

In compliance with a resolution of the Senate, a report on the second invention of Thomas S. Easton, for preventing explosions of steam-boilers.

AUGUST 19, 1842.
Read, and referred to the Committee on Printing.

AUGUST 22, 1842.
Referred to the Committee on Naval Affairs, and ordered to be printed.

NAVY DEPARTMENT, *August* 18, 1842.

SIR: In compliance with the resolution of the Senate of the 5th ultimo, I have the honor to transmit a copy of a report on the "second invention of Captain Easton to prevent the explosion of steam-boilers."

I am, with great respect, sir, your obedient servant,

A. P. UPSHUR.

Hon. W. P. MANGUM,
President of the Senate.

Report on Thomas S. Easton's second invention for preventing explosions in steam-boilers.

WASHINGTON, D. C., *August* 13, 1842.

SIR: Agreeably to your request, under date of the 6th of July last, I have made an examination of the second invention of Captain Thomas S. Easton to prevent the explosion of steam-boilers, referred to your Department by a resolution of the Senate of the United States, passed on the 5th of July; and I have now the honor to make known the results of that examination.

The objects of the invention and the construction of apparatus are set forth in a specification furnished by the inventor, of which the following is a copy:

"*Description of Easton's apparatus for the prevention of explosions in steam-boilers.*

"The object of this invention is to produce the discharge of all steam generated in a steam-boiler, above the amount required in safe practice, and to use the excess of steam to produce its own liberation. Also, to arrange the

Thomas Allen, print.

same apparatus so that it will indicate the want of water in the boiler at the moment it is reduced to a given line—all of which is placed beyond the control of the engineer or any other agency, either of accident or design, in the following manner:

"A steam-chest *C* is placed in the boiler on the top of the flue or flues, in which chest is a valve opening downward at *D*; the valve-stem *D* is attached to a lever *F* of the first order, having a fulcrum at *E*. To the lever at *F* is attached a weight corresponding with the pressure allowed to the boiler.

"To the steam-chest is affixed an escape-pipe *K*, leading through the boiler at any given point, and secured by a stuffing-box *L*, so that, when the steam exceeds the amount allowed, the valve in the chest is pressed downward, and the excess escapes into the chest, and thence by means of a pipe out of the boiler.

"The water is governed by floats, one or more being used according to the construction of the boiler. To the floats *H* are attached arms *I*, which are fastened to the fulcrum stake *E* by a pin-joint; said arms pass over the valve-stem in such manner that, when the water falls below a given point, the weight of the floats is brought to act on the valve by falling in contact with the pin, and acting as a lever of the second order in pressing the valve downward in opposition to the weight on the lever at *G*, and keeping the valve open until a supply of water is furnished to raise the floats and relieve the valve.

"The floats are to be placed in the central region of the boiler (between or on each side of the flues), so that the action of the water by motion will not affect their height.

"In the shell of the boiler is fixed a feeler *M*, being a rod with a button at its lower end, placed over the level *F* near the valve-stem, and used to ascertain at any time that the valve is free from obstruction.

"THOMAS S. EASTON.

"WASHINGTON CITY, *August* 4, 1842."

The above description will be rendered fully intelligible by the accompanying perspective drawing with its corresponding references, which very accurately represents the arrangement of apparatus with which my experiments have been conducted.

It is evident that, in this second invention, Captain Easton has aimed to secure one of the advantages proposed in the first, on which I have already had the honor to submit a report, namely, that of placing the means of safety beyond the reach of interference during the process of steaming. Another object is, to give notice of any deficiency of water in the boiler. This did not constitute any part of his first invention.

The inventor does not lay claim to any new principle of either mechanics, hydrostatics, or the science of heat.

The investigation consisted, therefore, in determining, by actual trial, certain practical effects which must result from the peculiar disposition of this mechanism, viz:

1. The degree of its uniformity of action in indicating the pressure of steam and the height of water.

2. The difference which ought to be allowed between the load on the ordinary safety-valve and that to be given to the valve of Captain Easton, in order that no unnecessary disturbance of the latter may occur in the ordinary running of the engine.

3. The action of floats, in cases of agitation or foaming of the water of a boiler consequent to the sudden discharge of steam.

4. To determine whether the movements of the engine intermitting the discharge of steam during a part of every revolution, will create any such agitation as will render ambiguous the indications of the floats.

5. Whether salt water is liable to corrode and cement the inner valve to its seat, increasing the difficulty of opening it, and thus interfering with its safety.

6. To determine what force may belong to any of the objections which may be raised against the employment of this apparatus.

1. The situation of a safety-valve placed in the interior of a boiler, is so entirely analogous to that of one on the exterior, that no question can exist, that if two valves have the same size and form, and are liable to transmit, when opened, nothing but steam, they will act under the same effective pressure. It is true that every solid body immersed in a medium denser than common air, will lose a portion of its effective weight proportionate to the increased density of that medium, and that steam is increased in specific gravity as its pressure is augmented; but in practice this can offer no serious impediment to the action of iron or leaden weights employed for this purpose.

In proceeding to make experiments on this subject, the first object was, to ascertain at what height the water must stand in the boiler, in order that the floats should bring their arms *I*, barely in contact with the lever of the safety-valve. This was found to be one eighth of an inch above the top of the flue. In practice, this may be obviously varied at pleasure, by varying the form and size of floats or the curvature given to the float-arms *H*. I may remark, in passing, that the hollow sheet-iron floats used in the present apparatus of the inventor, may probably be found, as heretofore, very difficult to maintain in good condition, on account of leakage, and therefore less useful than the counterpoised, submerged float of stone or other heavy material, so generally adopted elsewhere for similar purposes. Whichever is adopted, the principle of action will be the same.

Having filled the boiler to a sufficient height above this normal level, (which height was, for different purposes, varied from $1\frac{1}{2}$ to $3\frac{7}{16}$ inches), the manhole was closed, and the steam raised till it opened the inner valve. The weight on the outer safety-valve was then adjusted as to distance on the arm of its lever, so as to make an equilibrium with the same pressure, in order that both valves might rise nearly at the same moment. To have merely compared, however, one safety-valve with another, would not have answered any useful purpose, in deciding the first inquiry above stated. Recourse was accordingly had to the thermometer placed in a tube descending into the steam chamber, and more particularly to the manometer gauge, described in my report on Captain Easton's first invention (page 32); every arrangement for that part of the apparatus remaining in the same condition as during the experiments to verify the action on fusible alloys.

The weights carried by the inner valve, and under which it opened, were varied in the different series from 28.55 to 92.64 pounds per square inch. The inner valve actually used in these experiments had a diameter of one inch at the smaller base, and was consequently not more favorably formed for promptly obeying the action of the steam, than would be one adapted to a large working boiler, and having a less periphery in proportion to its area than the one now employed. Under every pressure while the water was so high above the flue as to keep the floats above the chance of contact with the valve-lever, the opening pressure was so nearly identical as to render the differences wholly unimportant, in regard to the total pressure borne by the boiler. It seldom in any series exceeded 5 or 6 pounds per square inch.

Thus, with a weight of 130 pounds on the outer safety-valve, the highest pressure when the inner safety-valve opened was 92.64 pounds per square inch, as determined by the gauge, and the lowest was 86.42 pounds, giving a difference of 6.22. This is altogether unimportant in a boiler adapted to bear a pressure of 100 or 150 pounds per square inch. It is doubtless to be attributed to the greater or less facility with which the friction of the junctures of the valve happens to be overcome.

With a weight of 120 pounds on the outer valve, the highest pressure to which it was found necessary to raise the steam in order to cause the inner valve to act, was 74 pounds per square inch, and the lowest was 67.8 pounds, exhibiting a difference of 6.2 pounds at the extremes. This was the result of 13 successive trials.

With $102\frac{1}{2}$ pounds on the outer valve, and a corresponding weight on the inner one, the highest of four opening pressures was 67.8 pounds, and the lowest 62.6, exhibiting a difference of 5.2 pounds between the extremes. At lower pressures the differences were still less. Thus, when $53\frac{1}{2}$ pounds weight was applied to the outer valve, the inner valve opened six times in succession, the true *bursting pressure* being at each time 35.68 pounds.

2. The difference to be allowed between the load on the common safety-valve, and that on the inner valve of Mr. Easton, will depend on the relation between the pressure which will *open* the latter valve, and that which will allow it to close; for below the latter point the load on the outer valve ought always to be kept.

For this determination a number of series of experiments was undertaken. In some of these, after having raised the pressure so high as to cause the inner valve to open in a brisk and decided manner, it was lowered either gradually, or by an intermitting action, until the valve closed spontaneously and completely; in others, after causing the valve to open by pressure, without aid from jarring, the tension of steam was gradually reduced, and the end of the lever *F*, from time to time, touched with the sliding-rod *M*, which, it will be observed, has the power to push down and open, but none to hold up or keep close, the valve attached to that lever. When, however, the pressure is sufficiently reduced to keep it firmly closed, this valve may often be found having an imperfect contact with its seat, and consequently giving vent to a considerable quantity of steam. If at this time the sliding-rod be quickly depressed, opening the valve for an instant, and then withdrawn, allowing it again to come briskly in contact with its seat, the escape of steam will be found entirely to cease. In this latter case a much less reduction of pressure was generally found necessary to cause the closing of the valve than when it was left to come *spontaneously*, that is, without extraneous interference, to a perfect bearing.

In a series of 15 comparative trials of opening and closing pressures, the following results were obtained, viz.:

The highest *opening pressure* was	33.43	pounds per square inch.		
The lowest " "	30.88	"	"	
The difference " "	2.55	"	"	
The highest *closing pressure* was	29.43	"	"	
The lowest " "	28.21	"	"	
And the difference "	1.22	"	"	

The mean of the 15 above opening pressures was 31.03.
The mean of the 15 above closing pressures was 28.55.
Showing, therefore, mean difference of 2.48.

During this series the utility of the sliding-rod to jar the valve and settle it into its seat, was made evident by an experiment in which the pressure of steam was reduced so far as to allow the valve to close spontaneously. This did not take place until the force was diminished to 25.59 or 2.96 pounds below what would have allowed the valve to close by jarring.

Hence, it appears that the "feeler" will settle the valve with about one half the reduction of pressure which would be required to close it completely without such aid.

In another series, consisting of six experiments, already referred to, the opening pressure was 35.68 pounds, and the closing pressure 33.43 pounds, exhibiting a difference of 2.25 pounds.

By the mean of three consecutive experiments of a third series, the opening pressure was 60.08 pounds, and the closing pressure was 55.17, exhibiting a difference of 4.91 pounds per square inch.

In a fourth set of trials, under a load still greater than any of the preceding, the valve opened when the pressure was at 62.6 pounds, and closed when it had fallen to 58.6, thus showing a difference of exactly 4 pounds per square inch.

In a series of 9 experiments, in which the pressure required to open the valve was 75 pounds, the weight which permitted it to close was 69.23 pounds, exhibiting a difference of 5.76 pounds per square inch. During this series the reduction required for spontaneous closing was to 62.17, or 7.06 pounds below that at which the sliding-rod caused the same effect to take place. Finally, in a series of ten experiments, during which the inner valve opened with scarcely a perceptible difference of pressure, under 86.42 pounds, it again closed with equal uniformity when the tension of steam had been reduced to 80.88 pounds per square inch, showing a difference of 5.54 pounds. Collecting together the above results, we have the following table of

Differences of opening and closing pressures.

Number of the comparison.	Number of experiments in the series.	Weight on the outer valve.	Opening pressure by manometer.	Closing pressure when sliding-rod was used.	Pressure at which the valve closed spontaneously.	Difference between opening and closing pressure by use of feeler.	Difference between spontaneous opening and closing pressure.
		Pounds.	P'ds per in.				
1	15	43.5	31.03	28.55	25.59	2.48	5.44
2	6	53.5	35.68	33.43	–	2.25	
3	3	90.0	60.08	55.17	–	4.91	
4	3	102.5	62.60	58.60	–	4.00	
5	9	122.0	75.00	69.23	62.17	5.76	12.83
6	10	130.0	86.42	80.88	–	5.54	

The sum of the differences in the seventh column is 24.94.

That of the closing pressure in the fifth is 325.86, showing that the difference due to friction is 7.6 per cent. of the pressure at which the force of steam made a fair *equilibrium* with the load upon the inner valve.

The sum of the two numbers in the eighth column compared with that of the corresponding ones in the fourth column, shows the former to be 17.2 per cent. of the latter; which proves that with an apparatus as well constructed as that with which my experiments were performed, we may, by ascertaining under what load on the outer valve the inner one will open, determine, by taking away 17.2 per cent. of that weight, the pressure under which the engine may run without danger of disturbing the inner valve, even when the steam is at its maximum working pressure.

It would, doubtless, be safe to allow the working load on the outer valve to be 20 per cent. below that under which the two valves will open simultaneously. The whole will, however, depend much on the smoothness and accuracy of the workmanship, and the entire freedom of the joints of the valve-stem and lever.

This was illustrated in one series of my experiments, in which, owing to some imperfection in the adjustment of the connecting pins, the differences between opening and closing pressures were much greater than any of the preceding.

Thus, in the 1st experiment—

The opening pressure was		48.98;	closing	40.27;	difference	8.71.
2d—	" "	52.71;	"	43.61;	"	9.10.
3d—	" "	54.35;	"	43.13;	"	11.22.

3. What has just been presented relates to the action of the valve unaffected by the floats. The experiments were in part performed when the floats were detached, so as to leave the valve wholly at liberty to obey pressure alone, and in part when the water in the boiler was known to be so high as to keep the floats aloof from contact with the lever.

It is well known, however, that when suddenly relieved from the pressure of highly elastic steam, water will always rise in foam and spray, and more particularly so if the liquid happen to contain any animal, vegetable, or argillaceous matter, giving it a degree of viscidity. The cause of this appearance is doubtless correctly referred to the fact, that when under the pressure of saturated and highly elastic steam, water has the same temperature as the steam itself; at which temperature it is, throughout the mass, constantly tending to assume the gaseous form. This form it can take only when relieved from the pressure of steam already generated. Until then, the mass of water preserves its density due to the temperature, whatever it may be, except in so far as the regular rising of bubbles of steam increases the bulk of the mass. But when a sudden relief causes the whole interior of the boiler to become filled with a mixture of steam and water with variable densities from the top to the bottom, it is evident that any solid mass of constant bulk, not partaking of the diminution of density thus momentarily given to the water on which it was reposing, must sink deeper into the attenuated mass than into that of which the density was sufficient to sustain it at the required level. Hence, whenever a violent agitation of this sort takes place, the floating mass may sink deeper than before, and on the cessation of foaming may acquire a vertical oscillating or dancing motion.

The evidence of this effect was rendered abundantly clear during my experiments, in which it was often found practicable to produce the opening of the inside valve by merely raising the common safety-valve attached to the boiler. This would take place not only when the pressure of steam was near the opening point, but often when far below it, and not only when the water was nearly exhausted, but sometimes considerably before that stage had arrived. As this result was produced under every separate weight to which the inner valve was subjected, it became only necessary to establish the negative proposition that the inner valve alone would not produce a discharge of steam, when, by the opening of the outside valve, foam was raised in the boiler.

Two series of trials were made in illustration of this part of the subject, in both of which the floats were detached. The first was made under about 30, and the second under 86 to 88 pounds per square inch, and in both with similar results. When the inside valve had been opened by carrying the pressure beyond the due limit, it continued to discharge steam with the same degree of force when the outside valve was opened, as it had done before, only influenced, of course, by the gradual reduction of pressure. There was none of that sudden *increase of flow* which had under similar circumstances been produced while the floats were attached. There was no opening of the inside valve consequent on opening the other, even when the water was very low, and the pressure near the opening point of the inner valve.

When that valve was already open and steadily emitting steam, the creation of foam on opening the outside one would cause some water to be emitted through the inner valve; but it flowed with the same steady current as the steam had done before, and did not come forth in gushes, as had happened when the floats were attached and the water getting low.

As the floats, when not supported by the water, were more than a counterpoise to the weight G, they would, of course, from the moment they brought their arms H in contact with the connecting bolt of the valve stem D, begin to counteract some part of that weight. As the water fell lower and lower by the gradual expenditure of steam, this portion of the weight G which rested on the valve bolt would of necessity be gradually increased, so that the actual pressures (as measured by the manometer) which would open the inside valve must be proportionally diminished. At every successive trial the water becoming more deficient, must cause the inner valve to close at lower pressures than any which preceded. This will be made evident by detailing one or two of the series which were made to elucidate this particular point.

The first was made by filling the boiler 2.5 inches above the flue, and loading the inner valve, so that the openings occurred at the following heights of the mercurial gauge.

1. Inner valve opened when	mercury was	25.10	inches,	closed at	24.43
2. After 4 minutes,	" "	25.29	"	"	24.53
3. " 3 "	" "	25.14	"	"	24.56
The mean of these three is	-	25.17	"		24.50
showing that the mean opening pressure	-	60.08 lbs.		closing	55.77
The 4th, took place in 2 minutes, at	-	25.04	inches,	closed	23.72
" 5th, " 4 "	-	24.73	"	"	23.92
" 6th, " 3 "	-	24.93	"	"	22.86
" 7th, " 5 "	-	24.33	"	"	22.71
" 8th, " 4 "	-	24.03	"	"	22.77
" 9th, " 5 "	-	24.13	"	"	21.80
" 10th, " 5 "	-	23.74	"	"	11.91

After the ninth experiment, the water was so nearly exhausted that the valve did not actually close at the tenth trial, even when the pressure was diminished to a column of 11.91 inches.

At the ninth experiment, the opening pressure *in pounds* had fallen to 52.71, and the *closing* to 40.38. This proves that the difference between opening and closing pressures are constantly on the increase, while the exhaustion of water proceeds, and while the *opening pressures* themselves are at the same time, and for reasons already explained, constantly diminishing.

The second series was commenced by raising the pressure so as to open with 25.44 inches of mercury (55 lbs. per inch), closing with 24.23.

The 2d trial, after	10 minutes, was at	-	24.73 inches,		closing	23.53
" 3d, "	6 "	-	24.68	"	"	22.01
" 4th, "	5 "	-	24.08	"	"	22.11
" 5th, "	4 "	-	24.88	"	"	22.31
" 6th, "	3 "	-	22.81	"		

When this last pressure (45.13 pounds per square inch) had been attained, the outer valve was opened and the foaming created caused the inner one also to start wide open. Hence the floats had taken a strong and decided action.

4. Having shown that when the floats were attached to the inner valve the latter could, under certain circumstances, be opened, by causing a sudden and copious discharge of steam from the outer valve to take place, even when the pressure was below the force which, if acting alone, would have been required to open the inner one, an important practical question arises as to *whether the customary discharges of steam from the boiler into the engine in the ordinary way of working at half stroke, would occasion any such agitation as might disturb the valve and interfere with its usefulness.*

To determine this point, the boiler was filled 2.9 inches above the top of the flue and the inner valve loaded to about 75 pounds on the square inch. When the pressure was at 40 pounds, the outside safety-valve was opened and closed forty times in one minute, dividing the time as equally as possible between the discharge and the retention of steam, thus imitating the action of an induction-valve of an engine. The fire was very brisk, and the opening given each time to the outer valve was sufficient to prevent any increase of pressure. On the contrary, it was reduced half an inch by the gauge. This produced no disturbance of the inner valve.

As the want of action on this valve might possibly be attributed to the excess of its weight beyond the pressure of steam to overcome it, the tension of steam was raised to 74 pounds per inch. The following trials were then made, allowing the pressure to accumulate to the same extent before commencing each trial:

1, making	45	discharges per minute, reduced the pressure		.2 inch.	
2, "	50	" " " "	"	.2	"
3, "	60	" (fire being moderate),	"	1.9	"
4, "	60	" (with a less opening each time),		.2	"

In none of these trials, was the least action produced upon the inner valve. Several quick and copious discharges were then made, reducing the pressure 1.7 inch, but still without effect.

On raising the pressure to 78 lbs., the valve opened spontaneously, and while the steam continued to issue, the following trials were made:

5, making	62	discharges per minute, reduced it	.4 inch,	or to	75 lbs.
6, "	56	" (in the next minute),	.8 "	"	66 "

The flow of steam through the inner valve continued gradually to diminish during all this time. No foaming of sufficient account to disturb the valve took place. Steam, and not water, came constantly from the pipe *K*.

Having reduced the pressure, and closed the inner valve, the fire was once more urged, and the force of the steam pushed to 79 pounds. Even then the valve did not rise; but the operations were recommenced with the safety-valve, making at the rate of 69 stiokes per minute, for 40 seconds. The pressure fell $4\frac{1}{2}$ pounds during that time, but the inner valve did not rise.

The action of the fire during these experiments was exceedingly brisk, and probably as much steam was formed by each square foot of the fire-surface of the boiler as would be obtained in practice in any boiler of similar construction, of whatever dimensions. Hence the probability of agitating the floats, and thereby disturbing the inner valve by an action precisely imitating that of the engine, was at least as great in this case as in that of any high-pressure boiler, working at the usual rates, and actually discharging its steam into the cylinder. *With the requisite supply of water, therefore, the experiments furnish no reason to apprehend serious inconvenience from foaming and disturbance of the floats, while using the cut-off principle on which steam is ordinarily employed.*

5. From all which has preceded, it may be inferred that, while in good condition, the valve of Captain Easton is capable of fulfilling its object, whether brought into play by the excessive pressure of steam, or by the diminished height of water. But, to ascertain whether the presence of saline substances could, within a limited time, cause any adhesion of the valve to its seat, and thus retard its action, two sets of trials were made, in which common salt was dissolved in the water till the contents of the boiler were considerably more dense than sea water.

With this water, the valve opened at sensibly the same pressures, as when clean water had been employed, and the same weight upon the lever.

A slight adhesion of the valve to its seat might possibly happen after long use.

In all practical cases, the interior valve would, of course, be constructed on a scale proportionate to the size of the boiler, and adequate to the discharge of all the steam which could possibly be produced. The peripheries of such valves would be less in proportion to their areas, than the one here used, which, as above stated, was but an inch in diameter. This would render their chances of adhering less than in the present case.

Should long practice demonstrate that the adhesion of the valve to its seat is an evil of any magnitude, it could be readily obviated by a simple mechanical arrangement attached to the steam-engine, which should, after every recurrence of a certain number of revolutions of the same, depress, for an instant, the sliding-rod *M*, and thus give a momentary opening to the inner valve. This would furnish, at short intervals, audible information that all was right within the boiler, and would inspire confidence while it secured safety.

6. *What valid objections, if any, can be raised against the employment of this invention?*

As represented in the accompanying sketch furnished by the inventor, and described in his specification, the sliding rod or "feeler" *M*, has at its lower extremity a button or disk, designed to prevent the rod from being driven through its stuffing box by the force of steam within. Were an engineer disposed to interfere with the proper action of the valve, he would have only to attach by its upper extremity a piece of chain to this button, and connect its lower end with that end of the lever F, which it is the office of the "feeler" to depress, and he would then, by properly adjusting the length of his chain, be able both to open the valve by pushing the rod down, and to close it and keep it closed by holding up the slide. This species of tampering might be prevented by omitting the button just spoken of; placing a stop outside of the boiler to prevent its being thrown out by the steam, and adjusting the length of the sliding rod so that it should, when drawn up, have its lower extremity entirely within the cavity of the stuffing box, through which it slides.

An objection has been urged against the use of floats in the boilers of sea-going steamers, on account of the surging of water within, consequent upon the rolling and pitching of the vessel. This Mr. Easton has sought to obviate by placing the floats in the central region of the boiler. Whatever force the objection may possess at sea, there can be little doubt that, on moderately calm waters, the arrangement proposed will be adequate to prevent such an evil.

If in a sea-going vessel one boiler were so situated and connected as to be able, by the careening of the ship, to empty its contents into another, the floats would, of course, intimate the danger in the exhausted boiler. The same would be true of a river boat not duly *trimmed*, either when at rest or in motion. Its usefulness would not, therefore, be limited to indicating the absolute quantity of water in the boilers.

If, either from the rolling and pitching of a vessel at sea, or from her careening in port, the floats should fail of fulfilling their precise function, that of proving the deficiency of water, they would not fail on the side of danger but always in favor of safety.

But whether the floats be or be not in all situations desirable appendages to the valve, the latter may, I think, be relied on for the proper discharge of its functions, and may be used in steam-vessels of every description.

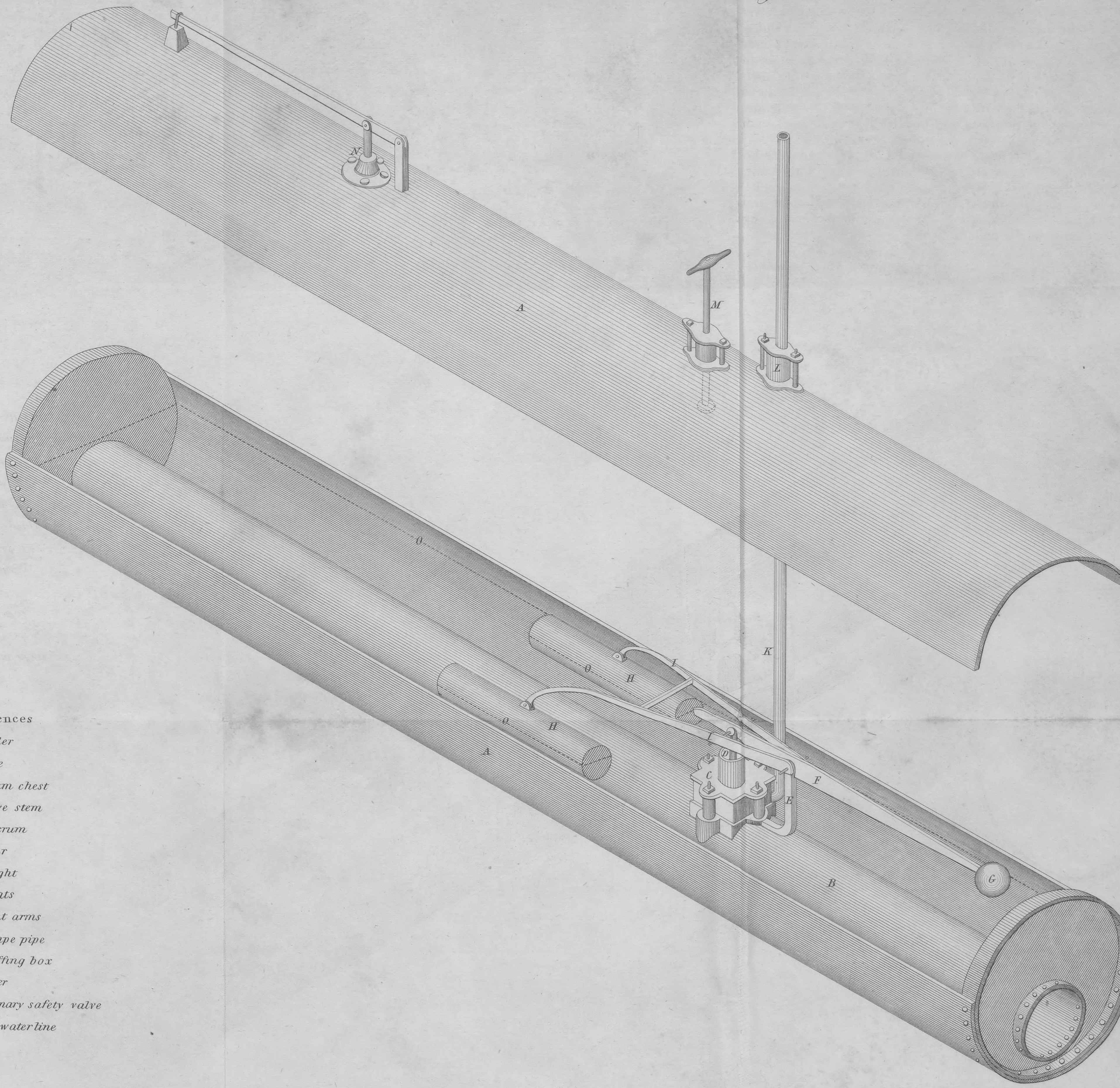
The arrangement of Captain Easton's whole mechanism is ingenious, sufficiently simple, and founded on well-known principles. Allowing the escape of steam and not of water, it discharges the source of danger, while it retains the means of safety. In these and many other respects it has decided advantages over his previously-patented invention, and merits the attention of the owners and managers of steam-engines and steam-vessels.

I have the honor to subscribe myself, very respectfully, your obedient servant,

WALTER R. JOHNSON.

Hon. A. P. Upshur,
Secretary of the Navy.

Thos. S. Easton's Steam Apparatus for preventing Explosions.



References

A. Boiler
B. Flue
C. Steam chest
D. Valve stem
E. Fulcrum
F. Lever
G. Weight
H. Floats
I. Float arms
K. Escape pipe
L. Stuffing box
M. Feeler
N. Ordinary safety valve
O. Low waterline